Burning Manure as an Economical Energy Source

A Senior Project

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Table of Contents

List of Tables

List of Figures

ABSTRACT

The dairy industry is under pressure from increasing environmental regulations, falling prices, as well as very aggressive foreign competition. Manure management and electrical costs are one area dairymen can look to cut costs. My objective for this project was to determine how cost effective biomass gasification of manure is at generating electricity. The proposed project was designed for a manure production equal to a 3,000 cow herd. I used standard capital budgeting techniques to determine the efficiency of the project, primarily focusing on the net present value, internal rate of return, and payback period.

INTRODUCTION

The current market for all of U.S. agriculture is under pressure from increasing regulation, falling prices, as well as very aggressive foreign competition. The current administration is trying to pass new environmental laws and regulations. At the same time trying to reduce government subsidies, it is determined to push through stricter regulations using the regulatory government agencies such as the EPA and USDA.

The dairy industry in particular is facing new challenges with low milk prices that have started to incline but with feed costs currently on the rise dairymen still are challenged to break even. This has meant that dairy farmers have had to borrow more money to maintain their herds while at the same time increasing the breakeven point they must get for their milk now and in the future.

Dairy farms must become more efficient. Dairy farmers must find solutions to ever increasing environmental regulations while at the same time lowering their costs of production. Successful dairy farmers often own multiple farms; while this is often successful it is not always the most effective solution. Adding more animals at the same location should be more efficient as well as cost effective. Generally availability of land and manure management is the limiting factors. Increasingly waste management is a major factor and concern of dairy farmers. Fines, threats, and an ever increasing regulatory burden take more of our time, energy and money.

How can dairies increase the point at which their operation is profitable? Is it possible to become profitable at $10.00 or $11.00 or is a $14.00 milk price necessary to break even.

Energy costs will continue to go up and costs are dictated to us by third parties of which we have no control over. Additionally handling of waste material and increasing regulation is another high cost that shows no indication of going down.

One possible method of increasing efficiency is to use manure, and waste feed to produce the electrical needs of the farm. Capturing solids before they go to the lagoons, and send all the waste to a boiler specifically designed and tested to burn high moisture waste. This system can provide electricity, heat and hot water.

LITERATURE REVIEW

What is Cogeneration

Cogeneration is the combined production of electrical power and heat energy. There are three main methods used to power electrical generators these include the steam turbine, gas turbine, or reciprocating engine. The heat energy that is generated can be used for whatever onsite needs there may be whether it's hot water, steam, or hot exhaust gases (Kutz, 2007). There are also three types of cogeneration systems; topping cycles, bottoming cycles, and combined cycles. A topping cycle system uses a mechanical device which fuel is used to power an electrical generator. This electricity may be used on-site or connected to the power grid for sale to the local community. The hot exhaust gases are routed to a steam generator to produce steam or hot water that can be used on site. The reason it considered a topping cycle is because the electrical energy is generated first at the high temperatures of the fuel combustion while the exhaust energy is used second to create the thermal energy. A bottoming cycle system uses the high temperature combustion energy for the heating process first then the lower temperature gases are used to produce electricity. The bottom cycle system is not as common because the difficulty with the low temperature electrical production. In a combined cycle system a gas turbine generates electrical power and the exhaust gas is routed to a boiler. The steam from the boiler then drives a steam generator which produces additional electrical energy. Then the exhaust steam from the turbine supplies the thermal energy for heating needs (Kutz, 2007).

Biomass gasification

Biomass gasification is a method of cogeneration that is being considered currently for the dairy industry to produce electrical needs of a dairy operation and at the same time removing waste in an environmentally friendly manner. This is the type of system that Ed Machado Dairy is considering investing in. Biomass gasification uses high temperatures and controlled levels of oxygen to gasify biomass into something called syn-gas. The syn-gas is used to help maintain the high temperatures which are required to create gasification of biomass. This high temperature gas heats up the fire tube boiler which generates the steam needed to spin the turbine electric generator. The biogas conversion process is formed by the production of heat making (Bopp, 2010). This makes it self-sustained meaning no external energy source is required aside from the initial startup of the process. Biomass gasification is also an environmentally sound method because the exhaust it produces meets the criteria for the toughest regulations and there is no water discharge involved, it also helps to reduce odors that have been cause of complaints for the dairy industry in the past. According to Dr. Sergio Capareda "Biomass, like fossil fuels, contains a lot of carbon and hydrogen and can be a good alternative energy source." However the biomass has the added benefit of being a renewable energy source (Schattenberg, 2009).

The only by-product that is left behind is beneficial and is in the form of ash, it is referred to as biochar. Biochar is a carbon rich product that has a wide assortment of uses. Biochar can be used to as a fertilizer to help replenish soil which can help improve the growth rate of crops. Capareda mentions, "Biochar is already known to be a useful soil supplement, especially around the Amazon rainforest, where its continued use creates what is called ‘terra preta’ or black earth.” (Schattenberg, 2009). Biochar could be used by the farmer to spread on fields or even possibly sold as a fertilizer.

The type of cogeneration system that this project employs is a topping cycle version where the electrical production is generated first from the high temperature fuel consumption

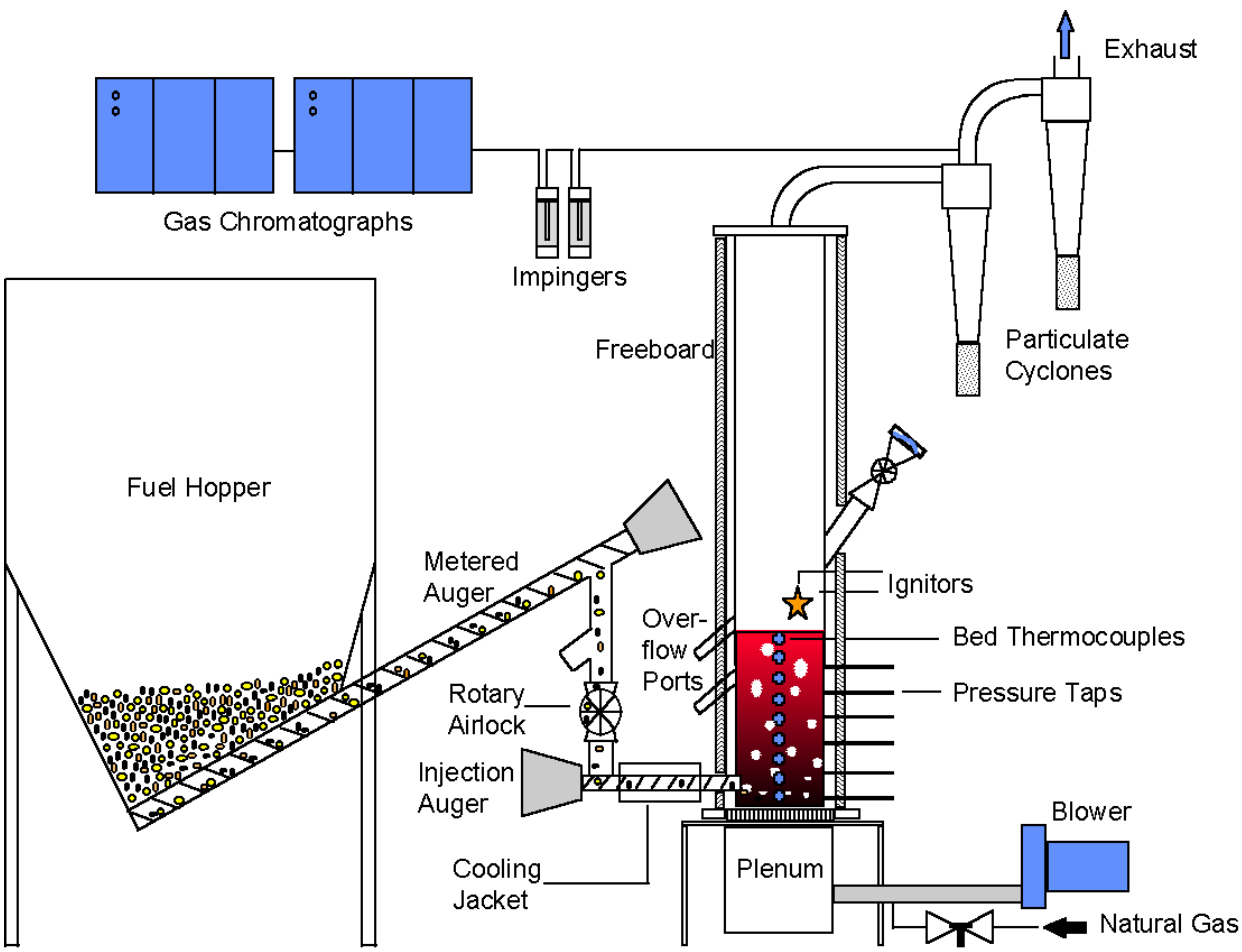

Figure 1 Example of Biomass Gasifier (Brown et al., 2002)

and the thermal energy is produced from the exhaust gasses. This system also uses an incline moving grate that feeds fuels in and works it down a “set of stairs” which provides agitation of the biomass which increases the combustion efficiency. The heat released is used to heat the fire tube boiler which generates the steam needed to spin the steam turbine generator which generates electricity (Bopp, 2010).

Alternative energy

Anaerobic Digesters. Methane energy is the primary alternative energy source used on dairies today. There are three types of anaerobic digesters, each with their own benefits and drawbacks. The covered lagoon digester makes up 27 percent of digesters in the United States. Some of the benefits of covered lagoons are low costs and proven reliability. However, they do have some drawbacks one of which is intolerance of hi-strength feed additives. Also, because they are generally not heated their operation varies by season with cooler seasons yielding less energy. Covered lagoons have low biogas and energy yields relative to other types of digesters (Anaerobic Digesters Continue to Grow in the U.S. Livestock Market, 2010).

Plug flow anaerobic digesters make up 26 percent of the market (Anaerobic Digesters Continue to Grow in the U.S. Livestock Market, 2010). Plug flow digesters are a long narrow tank that feedstock travels through and a fitted cover collects the biogas. They are heated so the season does not affect the yield which is one benefit. They are also relatively low in cost. However, they cannot tolerate sand bedding and are intolerant of mixed feed stocks. The final type of digester is a mixed plug-flow and it is the most popular making up 50 percent of all digesters in the United States. They consist of an in-ground concrete vessel. They are simple and cost effective great for dairy manure and are heated so seasonal temperature doesn't affect production. However this system does not tolerate sand (Bio Energy in Oregon, 2009).

As of 2009 it is estimated that there are some 140 anaerobic digesters operating on farms in the United States. These projects produce about 323,000 MWh annually on 126 farms. There are 14 other digesters that utilize boiler projects, pipeline injection, and other energy sources which generate an additional 55,500 MWh (Guide to Anaerobic Digesters, 2009). Government funding for anaerobic digesters has decreased from 2004 where the USDA contributed $9.5 million down to $3.6 Million in 2009. Energy production from digesters in the U.S. has increased from 20,000 MWh in the year 2000 to over 350,000 today (Anaerobic Digesters Continue to Grow in the U.S. Livestock Market, 2010). This means that the government funding is decreasing per mWh which makes digesters a less attractive option. While there are some 140 operational digesters in the United States there have been over 25 digesters that have been shut down, nearly 20 percent (Anaerobic Digester Database, 2010). Moreover there are 80 digesters that are planned or under construction however there have be some 37 of these that have been cancelled.

The reason for these cancellations and shutdowns of digesters is due to the complications and problems that many digesters face. The main reason for digester failure is excessive acid production which impairs bacterial populations and output of methane. The acid creates an environment that causes the bacteria to die off thus methane production decreases. Another problem that has caused the shutting down of digesters is that they are dependent on temperature. If the digester is in a climate that is too cool then the digester will not be able to produce the methane at an efficient rate. This is due to that fact that the bacteria that are degrading the manure and creating the methane are mesophiles which means they thrive in an environment that ranges from room temperature up to around 100F°. When temperature drops below this level the bacteria will not reproduce as fast and thus create less methane. This was the case of the cal poly dairy digester which was shut down. Located in the central coast temperature did not maintain a high enough level that could support the mesophilic bacteria population. Digesters can be heated but this requires a great deal of energy and is costly (Wright, 2001).

Plasma Arc Gasification. Plasma arc gasification is a new form of technology that turns biomass into plasma at extremely high temperatures. The basic requirements for a plasma arc gasification system involve a sealed vessel that is filled with a stable gas. The gas can be either nitrogen or, even ordinary air. Then a 650-volt current is passed between two electrodes creating an electric arc which pull electrons from the air (Plasma arc & Gasification). This converts the gas into plasma. The current flows through this newly formed plasma, creating a field of energy that is extremely powerful and is compared to the equivalent of lightening. The energy of the plasma arc is so powerful; it can turn trash, biomass, and basically anything into its basic elements by tearing apart their molecular bonds. What is left behind after biomass is passes through this plasma gasification process is a volcanic-like glass. This glass can be used as a raw material for several applications that range from bathroom tiles to an asphalt like product. Another beneficial by-product that is created during this process is a syn-gas much like the gas created from older forms of biomass gasification. It is a mix of hydrogen and carbon monoxide which can be converted into several types of useful fuels. Some of these fuels include ethanol, natural gas and hydrogen. A big bonus of this system is that it is self sustaining. It requires only the initial 650 volt current to start the cycle after that it produces its own electricity to create the electric arc, even if there is a blackout power outage. To produce electricity this system much like other methods of cogeneration, relies on heating water to generate steam and in turn spin a turbine that drives an electric generator (Behar, 2007).

At the current time this technology is mainly targeting the landfill waste segment. Our society is pushing towards more environmentally friendly technologies and this certainly is one. This technology has the ability of taking otherwise useless landfill waste and creating electricity at the same time slowing the growth of landfills and the pollution we leave behind. As for the dairy industry this technology is too costly to be feasible on a dairy operation. The system from the popular science article had a total cost of around $250,000,000. This system could handle around 2,000 tons an hour which is far more than even the largest dairy operations could produce. If they could extremely scale this back and reduce the equipment costs then it could be a possibility for the dairy industry in the future (Behar, 2007).

MATERIALS AND METHODS

Size Analysis

Manure production is a key factor for determining just how much electricity could potentially be generated. Average milk production per cow has increased 70% from 4,500 kg/cow/year in 1971 to nearly 7,300 kg/cow/year in 2000, resulting in changes in manure production (Nennich et al., 2003). According to expert Larry Bopp a cow produces 14 pounds of manure on a dry matter basis for lactating cows. Ed Machado Dairy is calculated at 3,000 cows. The reason that this 1,400 head lactating herd is estimated at 3,000 cows is because the facility houses all its replacement animals as well as the replacements for another 800 head herd. These 2,800 dry stock animals will be producing manure that is available for energy production. Ed Machado Dairy will be able to capture 100% of the manure and return approximately 6 cubic feet for bedding that will not be available for energy production. The reason 6 cubic feet of waste goes to bedding is due to the fact that this operation scrapes corrals during the dry months and stockpiles the dry manure for bedding free-stalls throughout the year. The manure that will fuel the biomass gasifier is targeted at 55% moisture content therefore adding in moisture a cow will produce 25.45lbs per day (Bopp, 2010).

Energy needs for Ed Machado Dairy are provided by Turlock Irrigation District. Records were pulled for the course of the past year to determine the average electrical consumption of the facility. Records were also analyzed to calculate average cost of electricity on a monthly basis as well as average cost per kilowatt hour.

Electrical Production

Electrical production is the cornerstone for this project. 1 British thermal unit (BTU) requires 6lbs of manure to be gasified. To convert BTU's to kilowatts of electricity there is a factor of .00029. This means that 3,448 lbs of manure at 55% moisture are required to produce one kilowatt of electricity. The project is in the preliminary stage and is planning a design that will have the capacity to burn 3,000 lbs per hour (Bopp, 2010).

Cost Benefit Analysis

Using three capital budgeting techniques that many firms utilize, a cost benefit analysis was performed. These techniques included net present value, simple rate of return, and internal rate of return. The net present value (NPV) technique is probably the most beneficial or accurate technique that a firm can use. The reason that the (NPV) is so beneficial is because it takes into account time value of money which is the fact that having money sooner is better than having money later. To find the net present value take the (total present value of cash inflows - total present value of cash outflows). In order to find the present values the formula used is: Present value*(1+discount rate)^(-year) (Brigham & Ehrhardt, 2010). In order to understand this formula for (NPV), the idea of present value needs to be explained. The present value of a cash flow due N years in the future is the amount which, if it were on hand today, would grow to equal the given future amount. For example an investment is guaranteed to return $1,500 over the course of N years, with the initial investment cost being $1,000. Since the $1,000 will grow to $1,500 in N years, $1,000 is the present value of $1,500 in N years.

Simple rate of return relates an investment to its estimated returns and produces a percentage of return. Simple rate of return however does not take into account time value of money. To find simple rate of return the formula used is (Incremental revenue/Initial investment + incremental costs). These incremental revenues would include monthly savings on the energy bill and possible monthly sales of electricity to the power grid. The initial investment is the cost to purchase all needed equipment and installation. The incremental costs include things such as normal maintenance and possible breakdowns. The internal rate of return (IRR) is an estimate of a projects rate of return or how fast it will pay back the investment. IRR also has the drawback of not including time value of money. In order to calculate the IRR I had to find the discount rate that sets the net present value equal to $0. This is just a matter of plugging numbers into the excel spreadsheet that I generated and finding the number that sets net present value = $0 (Brigham & Ehrhardt, 2010).

Payback Period

Payback period is a method that firms and businesses use to determine if an investment is feasible. It simply looks at how long it is projected that an investment or project will recuperate the money invested in it. A simple example of this would be an investment that requires $10,000 initially and returns $5,000 per year; the payback period would be two years. There are two basic drawbacks that the payback period has for judging an investment. It does not take into account the time value of money, and also does not look any further than the time that the investment is paid off. This means that profits after the investment is repaid are not taken into account (Brigham & Ehrhardt, 2010).

RESULTS AND DISCUSSION

Size Analysis

Figuring Ed Machado Dairy at roughly 3,000 head of lactating cows and assuming manure production is 14 lbs per cow per day on a dry matter basis it would put dry manure production at 42,000 lbs per day. The biomass gasifier can tolerate manure moisture levels up to 55%. At 55% moisture this puts average manure output per cow at 25.9 lbs per day and total daily manure production at 77,700lbs. Manure will be sent through a screw-press type separator to get moisture levels down to 55% (Bopp, 2010).

Over the course of the year the average monthly cost of electricity purchased from TID is $12,228. The average energy use for Ed Machado Dairy is 58,228 kWh per month. These two monthly averages put the average cost per kWh at $0.21

Electrical Production

Knowing that it takes 3,448lbs of manure to generate 1 Kilowatt of electricity and having an estimated manure production of 77,700 lbs per day including 55% moisture, there is an energy potential of generating 22.53 Kilowatts per day. That number would be a perfectly working system where 100% of manure production is utilized which is impossible. The proposed project is designed to handle 3,000 lbs of manure per hour or 72,000 lbs per day which puts energy production at approximately 20.88 kilowatts per day.

To put into perspective how much energy will be produced relative to how much energy is required by Ed Machado Dairy the monthly usage of kilowatt hours (kWh) needs to be converted to kilowatts. KWh equals power*time, this means that in order to find kilowatts all that is needed is to divide the average monthly usage by the time of the usage and it comes out to approximately 80.87 kilowatts per month. Expecting that the system can produce 20.88 kilowatts per day it will only take 3.87 days for the facilities needs to be met. This leaves 26.63 days of energy production that according to expert Larry Bopp can be sold to the energy supplier for approximately $.028 per kWh. There will be a total of 563.34 kilowatts of surplus; this converted comes out to 364,800 kWh. In terms of dollars this project it has the potential to generate monthly revenues on top of savings in the amount of $7,296 (Motors and drives, 2010).

Table 1. Monthly energy use and projected production

	Ed Machado dairy energy use	Projected energy production.
Average monthly kilowatt hours	58,228 kWh	458,500 kWh
Average monthly Kilowatts	80.87	636.86 kilowatts

Cost Benefit Analysis

The cost for the biomass gasification system with the steam turbine electrical generator is projected to be $1,450,000. There are other costs that go into implementing the equipment in order to get it to operate properly. A concrete manure pit will need to be constructed in order to pump the fresh manure slurry into the screw press. The manure pit is 30 feet in diameter and has a depth of 10 feet; the construction bid for this project is roughly $65,000. In order to drop manure moisture levels down to the 55% mark that the biomass gasifier requires, a screw-press type solids separator will need to be installed. The cost for the separator is $10,000. The total initial cash out flow with these three major components installed is $1,525,000. There is also an added annual cost of $10,000 for various maintenance and repair needs that have been seen in similar systems currently in use (Bopp, 2010).

The fact that this system can supply more than enough of the electrical needs for Ed Machado Dairy the average monthly bill will be 100% savings. This comes out to an annual energy savings of $146,736 worth. Adding to the savings the revenue generated from excess energy production of $7,296 monthly brings the total yearly cash inflows up to an impressive $234,288. Using a spreadsheet designed in excel simply plugging in the inflows and outflows shows all the numerical values for the capital budgeting methods.

The spreadsheets below outline three possible scenarios for this project. The first is a realistic projection for Ed Machado Dairy with a fairly high discount rate due to the amount of debt financing involved it also includes all excess energy to be sold back to the power grid. The second spreadsheet is the best case scenario with a lower discount rate which greatly affects the profitability of the project. The second scenario also has all extra energy being sold back to the power grid. The third spreadsheet shows a worst case scenario where the discount rate is the same as the first spreadsheet and the excess energy created by the gasification process is not able be sold back to the power grid.

Table 2. Realistic capital budgeting outcome with high discount rate

Capital budgeting for best case scenario							
Year	Cash Inflows	Present Value	Cash Outflows	Present Value	Payback Method Running Total	**Simple Rate of Return**	
0	$0.00		$1,525,000.00	$1,525,000.00	$0.00	4.882963934	
1	$234,288.00	$214,943.12	$10,000.00	$9,174.31	$234,288.00	Payback Year=	12
2	$234,288.00	$197,195.52	$10,000.00	$8,416.80	$468,576.00	Discount Rate=	9.0%

3	$234,288.00	$180,913.32	$10,000.00	$7,721.83	$702,864.00		
4	$234,288.00	$165,975.53	$10,000.00	$7,084.25	$937,152.00	**Net Present Value at i**	
5	$234,288.00	$152,271.12	$10,000.00	$6,499.31	$1,171,440.00	$887,746.80	
6	$234,288.00	$139,698.28	$10,000.00	$5,962.67	$1,405,728.00		
7	$234,288.00	$128,163.56	$10,000.00	$5,470.34	$1,640,016.00	**Internal Rate of Return**	
8	$234,288.00	$117,581.25	$10,000.00	$5,018.66	$1,874,304.00	14.645%	
9	$234,288.00	$107,872.70	$10,000.00	$4,604.28	$2,108,592.00		
10	$234,288.00	$98,965.78	$10,000.00	$4,224.11	$2,342,880.00		
11	$234,288.00	$90,794.30	$10,000.00	$3,875.33	$2,577,168.00		
12	$234,288.00	$83,297.52	$10,000.00	$3,555.35	$2,811,456.00		
13	$234,288.00	$76,419.74	$10,000.00	$3,261.79	$3,045,744.00		
14	$234,288.00	$70,109.86	$10,000.00	$2,992.46	$3,280,032.00		
15	$234,288.00	$64,320.97	$10,000.00	$2,745.38	$3,514,320.00		
16	$234,288.00	$59,010.06	$10,000.00	$2,518.70	$3,748,608.00		
17	$234,288.00	$54,137.67	$10,000.00	$2,310.73	$3,982,896.00		
18	$234,288.00	$49,667.59	$10,000.00	$2,119.94	$4,217,184.00		
19	$234,288.00	$45,566.60	$10,000.00	$1,944.90	$4,451,472.00		
20	$234,288.00	$41,804.22	$10,000.00	$1,784.31	$4,685,760.00		
21	$234,288.00	$38,352.49	$10,000.00	$1,636.98	$4,920,048.00		
22	$234,288.00	$35,185.77	$10,000.00	$1,501.82	$5,154,336.00		
23	$234,288.00	$32,280.53	$10,000.00	$1,377.81	$5,388,624.00		
24	$234,288.00	$29,615.16	$10,000.00	$1,264.05	$5,622,912.00		
25	$234,288.00	$27,169.87	$10,000.00	$1,159.68	$5,857,200.00		
26	$234,288.00	$24,926.49	$10,000.00	$1,063.93	$6,091,488.00		
27	$234,288.00	$22,868.34	$10,000.00	$976.08	$6,325,776.00		
28	$234,288.00	$20,980.13	$10,000.00	$895.48	$6,560,064.00		
29	$234,288.00	$19,247.82	$10,000.00	$821.55	$6,794,352.00		
30	$234,288.00	$17,658.55	$10,000.00	$753.71	$7,028,640.00		
31	$234,288.00	$16,200.51	$10,000.00	$691.48	$7,262,928.00		
32	$234,288.00	$14,862.85	$10,000.00	$634.38	$7,497,216.00		
33	$234,288.00	$13,635.64	$10,000.00	$582.00	$7,731,504.00		
34	$234,288.00	$12,509.76	$10,000.00	$533.95	$7,965,792.00		
35	$234,288.00	$11,476.85	$10,000.00	$489.86	$8,200,080.00		
36	$234,288.00	$10,529.22	$10,000.00	$449.41	$8,434,368.00		
37	$234,288.00	$9,659.83	$10,000.00	$412.31	$8,668,656.00		
38	$234,288.00	$8,862.23	$10,000.00	$378.26	$8,902,944.00		
39	$234,288.00	$8,130.49	$10,000.00	$347.03	$9,137,232.00		
40	$234,288.00	$7,459.16	$10,000.00	$318.38	$9,371,520.00		

Total	$7,446,520.00	$2,520,320.41	$1,925,000.00	$1,632,573.60			

Table 3. Best case scenario with low discount rate

Capital Budgeting							
YR	Cash Inflows	Present Value	Cash Outflows	Present Value	Payback Method Running Total	**Simple Rate of Return**	
0	$0.00		$1,525,000	$1,525,000	$0.00	4.882963934	
1	$234,288.00	$226,365.22	$10,000.00	$9,661.84	$234,288	Payback Year=	12
2	$234,288.00	$218,710.35	$10,000.00	$9,335.11	$468,576	Discount Rate=	3.5 %
3	$234,288.00	$211,314.35	$10,000.00	$9,019.43	$702,864		
4	$234,288.00	$204,168.46	$10,000.00	$8,714.42	$937,152	**Net Present Value at i**	
5	$234,288.00	$197,264.21	$10,000.00	$8,419.73	$1,171,440	$3,264,686	
6	$234,288.00	$190,593.44	$10,000.00	$8,135.01	$1,405,728		
7	$234,288.00	$184,148.25	$10,000.00	$7,859.91	$1,640,016	**Internal Rate of Return**	
8	$234,288.00	$177,921.01	$10,000.00	$7,594.12	$1,874,304	7.8770%	
9	$234,288.00	$171,904.36	$10,000.00	$7,337.31	$2,108,592		
10	$234,288.00	$166,091.17	$10,000.00	$7,089.19	$2,342,880		
11	$234,288.00	$160,474.56	$10,000.00	$6,849.46	$2,577,168		
12	$234,288.00	$155,047.89	$10,000.00	$6,617.83	$2,811,456		
13	$234,288.00	$149,804.72	$10,000.00	$6,394.04	$3,045,744		
14	$234,288.00	$144,738.86	$10,000.00	$6,177.82	$3,280,032		
15	$234,288.00	$139,844.31	$10,000.00	$5,968.91	$3,514,320		
16	$234,288.00	$135,115.27	$10,000.00	$5,767.06	$3,748,608		
17	$234,288.00	$130,546.16	$10,000.00	$5,572.04	$3,982,896		
18	$234,288.00	$126,131.55	$10,000.00	$5,383.61	$4,217,184		
19	$234,288.00	$121,866.24	$10,000.00	$5,201.56	$4,451,472		
20	$234,288.00	$117,745.16	$10,000.00	$5,025.66	$4,685,760		
21	$234,288.00	$113,763.44	$10,000.00	$4,855.71	$4,920,048		
22	$234,288.00	$109,916.36	$10,000.00	$4,691.51	$5,154,336		
23	$234,288.00	$106,199.38	$10,000.00	$4,532.86	$5,388,624		

24	$234,288.00	$102,608.10	$10,000.00	$4,379.57	$5,622,912		
25	$234,288.00	$99,138.26	$10,000.00	$4,231.47	$5,857,200		
26	$234,288.00	$95,785.76	$10,000.00	$4,088.38	$6,091,488		
27	$234,288.00	$92,546.63	$10,000.00	$3,950.12	$6,325,776		
28	$234,288.00	$89,417.03	$10,000.00	$3,816.54	$6,560,064		
29	$234,288.00	$86,393.27	$10,000.00	$3,687.48	$6,794,352		
30	$234,288.00	$83,471.76	$10,000.00	$3,562.78	$7,028,640		
31	$234,288.00	$80,649.04	$10,000.00	$3,442.30	$7,262,928		
32	$234,288.00	$77,921.78	$10,000.00	$3,325.90	$7,497,216		
33	$234,288.00	$75,286.74	$10,000.00	$3,213.43	$7,731,504		
34	$234,288.00	$72,740.81	$10,000.00	$3,104.76	$7,965,792		
35	$234,288.00	$70,280.98	$10,000.00	$2,999.77	$8,200,080		
36	$234,288.00	$67,904.33	$10,000.00	$2,898.33	$8,434,368		
37	$234,288.00	$65,608.05	$10,000.00	$2,800.32	$8,668,656		
38	$234,288.00	$63,389.42	$10,000.00	$2,705.62	$8,902,944		
39	$234,288.00	$61,245.81	$10,000.00	$2,614.13	$9,137,232		
40	$234,288.00	$59,174.70	$10,000.00	$2,525.72	$9,371,520		
	$7,446,520	$5,003,237	$1,925,000	$1,738,550			

Table 4. Worst case scenario

Capital Budgeting							
Year	Cash Inflows	Present Value	Cash Outflows	Present Value	Payback Method Running Total	**Simple Rate of Return**	
0	$0.00		$1,525,000.00	$1,525,000.00	$0.00	2.586518033	
1	$146,736.00	$134,620.18	$10,000.00	$9,174.31	$146,736.00	Payback Year=	11
2	$146,736.00	$123,504.76	$10,000.00	$8,416.80	$293,472.00	Discount Rate=	9.0%
3	$146,736.00	$113,307.12	$10,000.00	$7,721.83	$440,208.00		
4	$146,736.00	$103,951.48	$10,000.00	$7,084.25	$586,944.00	**Net Present Value at i**	
5	$146,736.00	$95,368.33	$10,000.00	$6,499.31	$733,680.00	-$54,081.60	
6	$146,736.00	$87,493.88	$10,000.00	$5,962.67	$880,416.00		
7	$146,736.00	$80,269.62	$10,000.00	$5,470.34	$1,027,152.00	**Internal Rate of Return**	
8	$146,736.00	$73,641.85	$10,000.00	$5,018.66	$1,173,888.00	8.640%	
9	$146,736.00	$67,561.33	$10,000.00	$4,604.28	$1,320,624.00		

10	$146,736.00	$61,982.87	$10,000.00	$4,224.11	$1,467,360.00		
11	$146,736.00	$56,865.02	$10,000.00	$3,875.33	$1,614,096.00		
12	$146,736.00	$52,169.74	$10,000.00	$3,555.35	$1,760,832.00		
13	$146,736.00	$47,862.15	$10,000.00	$3,261.79	$1,907,568.00		
14	$146,736.00	$43,910.23	$10,000.00	$2,992.46	$2,054,304.00		
15	$146,736.00	$40,284.61	$10,000.00	$2,745.38	$2,201,040.00		
16	$146,736.00	$36,958.36	$10,000.00	$2,518.70	$2,347,776.00		
17	$146,736.00	$33,906.75	$10,000.00	$2,310.73	$2,494,512.00		
18	$146,736.00	$31,107.11	$10,000.00	$2,119.94	$2,641,248.00		
19	$146,736.00	$28,538.64	$10,000.00	$1,944.90	$2,787,984.00		
20	$146,736.00	$26,182.24	$10,000.00	$1,784.31	$2,934,720.00		
21	$146,736.00	$24,020.40	$10,000.00	$1,636.98	$3,081,456.00		
22	$146,736.00	$22,037.06	$10,000.00	$1,501.82	$3,228,192.00		
23	$146,736.00	$20,217.49	$10,000.00	$1,377.81	$3,374,928.00		
24	$146,736.00	$18,548.16	$10,000.00	$1,264.05	$3,521,664.00		
25	$146,736.00	$17,016.66	$10,000.00	$1,159.68	$3,668,400.00		
26	$146,736.00	$15,611.61	$10,000.00	$1,063.93	$3,815,136.00		
27	$146,736.00	$14,322.58	$10,000.00	$976.08	$3,961,872.00		
28	$146,736.00	$13,139.98	$10,000.00	$895.48	$4,108,608.00		
29	$146,736.00	$12,055.03	$10,000.00	$821.55	$4,255,344.00		
30	$146,736.00	$11,059.66	$10,000.00	$753.71	$4,402,080.00		
31	$146,736.00	$10,146.48	$10,000.00	$691.48	$4,548,816.00		
32	$146,736.00	$9,308.69	$10,000.00	$634.38	$4,695,552.00		
33	$146,736.00	$8,540.09	$10,000.00	$582.00	$4,842,288.00		
34	$146,736.00	$7,834.94	$10,000.00	$533.95	$4,989,024.00		
35	$146,736.00	$7,188.02	$10,000.00	$489.86	$5,135,760.00		
36	$146,736.00	$6,594.51	$10,000.00	$449.41	$5,282,496.00		
37	$146,736.00	$6,050.01	$10,000.00	$412.31	$5,429,232.00		
38	$146,736.00	$5,550.47	$10,000.00	$378.26	$5,575,968.00		
39	$146,736.00	$5,092.17	$10,000.00	$347.03	$5,722,704.00		
40	$146,736.00	$4,671.72	$10,000.00	$318.38	$5,869,440.00		
Total	$3,944,440.00	$1,578,492.01	$1,925,000.00	$1,632,573.60			

These spreadsheets took cash inflows and cash outflows over a 40 year time period. From the spreadsheet it is easy to see the outcomes of the capital budgeting techniques highlighted in individual colors. We see that the realistic returns net present value (highlighted in red) offer a significant profit calculated to be $887,746.80 over the course of forty years. The best case scenario with the lower discount rate has an excellent net present value of $3,264,686. The worst case scenario had by far the worst net present value showing a loss of $54,081.60. Through these three scenarios it is easy to see how drastically the discount rate affects the profitability of this project. It shows that the 3.5% rate has a $2.3 million advantage over the 9% rate. These scenarios also show the affects of yearly cash inflows on profitability. The last scenario with none of the extra energy being sold back to the grid results in an $87,552 reduction of yearly cash inflow dropping the net present value into negative returns. According to net present value the first two scenarios would be approved while the last scenario would be declined.

The simple rate of return (highlighted in purple) is unaffected by the change in discount rate as proven from the top two scenarios having an equal return of 4.88%. The simple rate of return is affected by the decrease in cash inflows showing a decreased return of 2.59%. The reason that the simple rate of return is unaffected by a change in discount rate is due to the fact that it does not consider the time value of money.

Highlighted in orange the IRR is calculated by setting the net present value equal to zero. As with simple rate of return the discount rate does not affect IRR because it does not take into account time value of money. The first two scenarios have an IRR that comes out to 14.645%. The worst case scenario however is affected due to the decrease in revenues which drops the IRR to 8.64%

Payback Period

The payback period (highlighted in blue) for the proposed project on Ed Machado Dairy will optimally be seven years to pay for the entire initial investment. The top two scenarios share the same seven year payback period because the payback period technique lacks the consideration of time value of money.   For an investment such as this, seven years is a short amount of time to recuperate all of the initial funds. The worst case scenario does have a lengthened payback period of eleven years due to the lower yearly revenues. Eleven years however is a very reasonable payback period for an investment such as this.

CONCLUSION

Biomass gasification has many promising attributes for the dairy industry. It can produce electrical needs for a dairy operation in an environmentally friendly manner, while utilizing a renewable fuel source. Another financial benefit is that any excess energy could possibly be sold back to the power grid to generate extra revenues. Biomass gasification also produces a beneficial by-product for any dairy operation that farms. The capital budgeting techniques demonstrate some very solid profitability for the proposed project. Based off of the capital budgeting I would recommend the investment to Ed Machado Dairy as long as the ability to sell the excess energy back to the grid is guaranteed. These projected numbers seem to be very promising however there is still a great deal of risk involved. The fact that this is a new application for the technology could mean that there will be some complications and the equipment could not work as soundly as projected. This could lead to breakdowns and extra repair costs or even failure. There will need to be a very solid warranty and a trial period to determine if the equipment works as well as it is planned.

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